expertise a significant number are treated with Ilizarov framing (21.1%). 109 patients sustained a compound injury of which 30% required re-admission. The overall complication rate was 5.68%. (Intra-medullary nailing complication rate 8.63%, Ilizarov 2.27% and ORIF 4.34%.) However, for each individual complication it was less than 1%. This is similar to published complication rates.

Conclusion: The experience of the Royal Victoria Hospital is applicable and comparable to any other industrialised nation. The main change has been the increase in low energy osteoporotic fracture, 24.3% in Belfast 2007 and 20.3% in Edinburgh 1995. This study confirms several valid treatment options for tibial shaft fractures depending on local expertise and fracture patterns. All treatment modalities have an acceptably low complication profile. The use of pre-contoured tibial plates is likely to increase and consequent outcomes measured.

doi:10.1016/j.injury.2010.07.437

1A.24

Availability of "in hours" trauma theatres and its effect on the management of open lower limb fractures: experience from a level 1 trauma centre

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Introduction: The management of open lower limb fractures requires a multidisciplinary approach and should ideally be undertaken at a centre where appropriate surgical expertise is available. In the last 5 years the importance of early debridement within 6 h of injury has been questioned, especially if appropriate antibiotic therapy is commenced expeditiously. We sought to establish what effect the changing philosophy surrounding these injuries, in tandem with an increased availability of "in hours" trauma provision has had on the management of these injures in a level 1 trauma centre.

Method: An initial audit of the management of open lower limb fractures admitted directly to our institution over a 12-month period (June 2004–2005 (32 patients)) was performed. Following implementation of the recommendations of the primary audit, which included greater access to planned trauma sessions and minimising operating "out of hours", a re-audit was performed (January 2008–2009 (27 patients)). Between these audit periods the planned trauma operating provision increased from 42.5 h to 66.5 h/week.

Results: The re-audit highlighted a number of changes in practice. Fewer patients underwent initial surgery within the 6-h window, but all had initial debridement within 24 h. No surgery was performed between 0000 and 0900. Cases were instead deferred to the morning trauma list (Table 1). At initial debridement Orthopaedics and Plastic surgical consultants were present at a higher percentage of cases.

Conclusion: The findings from our audit reflect recent changes in philosophy regarding open lower limb fractures. With increased availability of planned emergency operating sessions there has been a shift away from the "6-h rule" with a conscious decision made to defer surgery until staff with the appropriate expertise are available. This approach has not led to an unacceptable delay until initial debridement and has increased the number of cases were a consultant is present.

Table 1

	Time to operation			
	<6 h	6–24 h	>24 h	Mean Time (Range)
June 2004–2005	14 (42.8%)	15 (46.9%)	3 (9.4%)	12.5 h (2–70)
January 2008–2009	6 (22.2%)	21 (77.8%)	0 (0%)	9.75 h (2–24)

doi:10.1016/j.injury.2010.07.438

1A.25

Internal fixation of long-bone non-union: is bone graft necessary?

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Non-union occurs in 5–10% of all fractures. A variety of mechanical and biological factors cause healing to stop whilst the fracture is still present and the fracture will not unite without surgical intervention. It is usually established between 6 and 8 months but the absence of progressive healing can often be observed at an earlier time. A variety of methods can be used to treat non-unions. Stable fixation is essential and many authors recommend the addition of bone graft. The aim of the current study was to evaluate the results of internal fixation for long-bone fractures and assess the impact of bone graft on union rates.

All patients undergoing internal fixation of a non-union under the care of a single surgeon over a 13-year period were identified. Patients were treated according to AO principles with careful preoperative planning. In general, non-unions with an intramedullary nail were treated by exchange, reamed nail. Plate fixation included Judet decortication and compression with the articulated compression device and lag screws. Early in the series, the surgeon used traditional, iliac crest bone graft techniques but with increasing experience the use of bone graft became less common.

An independent case-note and radiological review was performed and data collected on a standard proforma.

108 cases were identified. The mean age was 42 years (range 15–85 years) and 69% were male. Mean time from fracture to definitive non-union treatment was 14 months. 80% were isolated injuries and 20% associated with polytrauma. The fracture site was the clavicle ($n = 18$); humerus ($n = 20$); radius and ulna ($n = 5$); femur ($n = 35$) and tibia ($n = 30$). The primary fracture treatment was non-operative ($n = 40$); IM nail ($n = 39$); plate fixation ($n = 21$) and external fixation ($n = 8$). Deep infection was present in 11 cases.

To treat the non-union, compression plating was used in 78 cases and exchange nailing in 30. Bone graft was used in 41 cases, only 1 of which was an exchange nail. 73 non-unions treated with compression plating healed (94%) and 27 non-unions treated by exchange nailing healed (90%) ($p = 0.24$). The mean time to radiological union was 6.8 months. By anatomical site, the union rates were: clavicle 100%; humerus 95%; radius and ulna 100%; femur 86% and tibia 93%. In those treated with a compression plate without bone graft the union rate was 92% whilst the addition of bone graft resulted in a union rate of 95% ($p = 0.60$). Complications included deep infection ($n = 3$), superficial wound infection ($n = 4$) and transient nerve palsy ($n = 3$). For infected non-union, the infection was cured in 8 of 11 cases (73%).

In conclusion, this study demonstrates that union rates of over 90% can be obtained if non-unions are treated by internal fixation using AO principles. The routine use of autologous bone graft may not be necessary and, based upon the union rates observed in this study, a prospective randomised study to evaluate the use of bone graft in non-union surgery would need a sample size of 2200 (1100 in each group) to detect a significant increase in union with 80%

power. In terms of NNT, we would need to give 34 patients a bone graft to prevent one additional failure of healing.

doi:10.1016/j.injury.2010.07.439

1A.26

"Cut and run". Rapid life saving amputation using fire service hydraulic cutting equipment in entrapped trauma victims

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Background: We investigated the potential to utilise fire service hydraulic cutting equipment to effect life saving amputations in entrapped trauma victims.

Materials and methods: After a successful pilot study using four cadaveric porcine hind-leg models; three fresh frozen bequeathed cadaveric lower limb specimens each underwent five guillotine amputations using the hydraulic cutting equipment and conventional war surgical techniques. Video-documentation of each guillotine amputation was studied to define the: (i) number of cutting actions required to complete the amputations without the need for other cutting instruments, (ii) total time to achieve a completed amputation, (iii) quality of cut and (iv) proximal extent of fracture propagation.

Results: Our study confirms that this equipment would enable extrication from immediately life threatening circumstances between two and seven times quicker than conventional amputation techniques.

Conclusion: The equipment allows effective access to facilitate maximal stump length preservation and protects attending staff and the injured patient from the dangers of conventional amputation techniques in these difficult circumstances.*Keywords*: Life saving; Amputation; Hydraulic; Cutting; Equipment

doi:10.1016/j.injury.2010.07.440

1A.27

A robotic hexapod external fixator for the correction of angular deformity of long bones

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Introduction: External fixation is a commonly used technique for fracture fixation as well as for limb lengthening and correction of deformities either congenital or caused by trauma. Fracture treatment primarily requires immobilization and anatomical reduction of the fracture gap, while distraction osteogenesis utilizes exact fixator movements to gradually form new tissue. The gradual distraction stimulates the body's self-healing capacities to form new bone and has been proposed for limb lengthening and treatment of deformities already 100 years ago. The hexapod external fixator is based upon parallel kinematics well-known from high-precision robotics. This allows for fracture movements in all six degrees of freedom without losing stability of fixation. In current clinical routine the fixator movements are effected manually by the patient several times a day over the course of healing. A system is presented to improve the treatment with robotic actuators replacing the manual actuation.

Fig. 1. Robotic hexapod external fixator (shown with power study and control software on netbook).

Patients and methods: The hexapod external fixator is based upon parallel kinematics. Six linear manual actuators (distractors) are fixed on two rings with nonblocking ball joints. External fixators described by Ilizarov still in common use loose stability while being adjusted as hinges have to be unblocked to allow movements of the device. Due to the parallel kinematics the hexapod external fixator always maintains stability of fixation thus allowing even complex fracture movements without patient discomfort. A motor-driven actuator was developed to replace the manual actuation elements of the fixator system. The actuators are assembled from two main parts: the telescopic bar also used in the manual system and a motor unit. It contains a small electric motor (Maxon RE13) with three watts of electrical power, a magnetic encoder and a planetary gear head (Fig. 1). The motor unit is housed in a watertight polyurethane/composite enclosure made with a ZPrinter 450 (Z Cooperation) rapid prototyping system. It is attached to the telescopic bar with a clip-on technique. The speed of the linear actuators is up to 2.5 mm per second while the force of the robotic external fixator is in distraction is typical 300 N.

Accuracy of the robotic fixator is identical to the manual system with a typical error of less than 1° and 1 mm respectively. The robotic hexapod external fixator was applied clinically for the final adjustment of a distraction osteogenesis. A male patient of 35 years suffered a fracture of his left lower leg in 2000. The fracture was treated with an Ilizarov external fixator yet a shortening of 1.5 cm and varus deformation remained.

In April 2009 tibia and fibula were cut and distraction osteogenesis was initiated to correct the shortening and deformity. The patient was not fully compliant due to pain developing during actuation. Therefore the distraction osteogenesis was finished prematurely and the hexapod fixator was scheduled to be removed in May 2009.

Results: Upon removal of the manual hexapod external fixator the robotic system was applied (Fig. 2) to correct the remaining angular deformities under fluoroscopic control.

An angle of 3.5° in varus and 13.3° posterior deformity was determined with two X-ray images taken from frontal and lateral.

After robotic reduction the varus deformity was corrected successfully while the posterior deformity was reduced to 6°. Shortening of the leg was not corrected.